WATERSHED REHABILITATION IN THE AIRSTRIP CREEK BASIN

REDWOOD NATIONAL PARK
WATERSHED REHABILITATION

TECHNICAL REPORT 2
FEBRUARY 1981

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ACKNOWLEDGEMENTS

We thank the following for their review of this report: Lisa Babcock, Danny Hagans, Mary Hektner, Lee Purkerson, Don Reeser, Mark Seltenrich, Ron Sonnevil, Steve Veirs, and Bill Weaver. David Best spent two field days retaking photographs from photo points and surveying sediment volumes. Frequent communication with individuals associated with Integrated Forest Management immeasurably improved our ability to document this project and the costs; and we are especially grateful to Kathy Sartorius and Jo Lynn Smith for their cooperation. We thank John Sacklin for editing, Tom Marquette for preparing graphics, and the Arcata office staff for typing.

DATA SUMMARY

Type of Project:

Erosion Control, Watershed Rehabilitation

Location:

Upper (Northeast) Portion of Airstrip Creek
Redwood National Park
Redwood Creek Basin
Humboldt County, California

Project Site Description:

One-hundred sixty (160) acres of prairie, tractor logged timberland, and an associated network of logging roads and ranch roads.

Project Duration:

August 1, 1979 to May 1, 1980

Method of Work Execution:

Request for Proposal Contract and a Cost-Reimbursement Contract.

Major Work Tasks of Project:

Excavation of road fill placed in stream crossings, general clearance of debris from stream channels, construction of a sediment collection system, placement of straw mulch and jute netting on freshly disturbed soils, revegetation of bare slopes and maintenance of erosion control work through the first winter season.

Contractor:

Integrated Forest Management, Incorporated
P.O. Box 2694
McKinleyville, California 95521

Contracting Agency:

National Park Service
Redwood National Park
P.O. Box SS
Arcata, California 95521

Contract Amount:

$91, 141.18

I. INTRODUCTION

A. Background

This report describes erosion control work performed in the Airstrip Creek basin between August 1979, and May 1980, and evaluates the effectiveness of this work as of August 1980. Work effectiveness is analyzed in terms of erosion control and cost. Evaluation of project work is largely confined to the effectiveness of erosion control measures exclusive of the revegetation efforts. Revegetation is not addressed because one year is not enough time to evaluate success of vegetation in terms of erosion control.

The Airstrip Creek rehabilitation unit was one of four separate sites subject to erosion control and watershed rehabilitation work within Redwood National Park during 1979. The unit was unique in that the work was performed under a Request for Proposal (RFP) type contract where the contractor prescribed all the treatments and then, upon approval, executed them on the site.

The rehabilitation unit consists of the upslope, 160 acre portion of the Airstrip Creek drainage basin, located within the Redwood Creek watershed (Figures 1 and 2). The Park Service selected the site for a RFP contract because erosion problems in upper Airstrip Creek needed treatment, yet the site was separated from Redwood Creek by 3,600 feet of old-growth redwood forest. Erosion and erosion control treatments therefore could not deliver sediment directly to Redwood Creek. Treatments on more critical sites adjacent to Redwood Creek are prescribed by Park Service staff in order to have as much control over rehabilitation methods as possible.

Most of the upper Airstrip Creek drainage was tractor logged by Arcata Redwood Company in 1971. The lower, southernmost part of the rehabilitation unit was tractor logged by Simpson Timber Company in 1974 (Figure 2). The land logged in 1971 was aerially seeded with conifer seeds in 1971 and 1972. Stocking of young conifers on the Airstrip Creek unit appears generally good.

Rehabilitation work involved three phases. Phase one work included building waterbars, clearing stream channels, and using heavy equipment to excavate debris from stream crossings. Phase two work involved channel stabilization in areas modified by heavy equipment as well as revegetation work on bare soil areas. Phase one and phase two work occurred during August, September and October, 1979. Average crew size for the first two phases was 12 people. Phase three was winter maintenance of structures and erosion control work and lasted from October through the end of the contract on May 1, 1980.

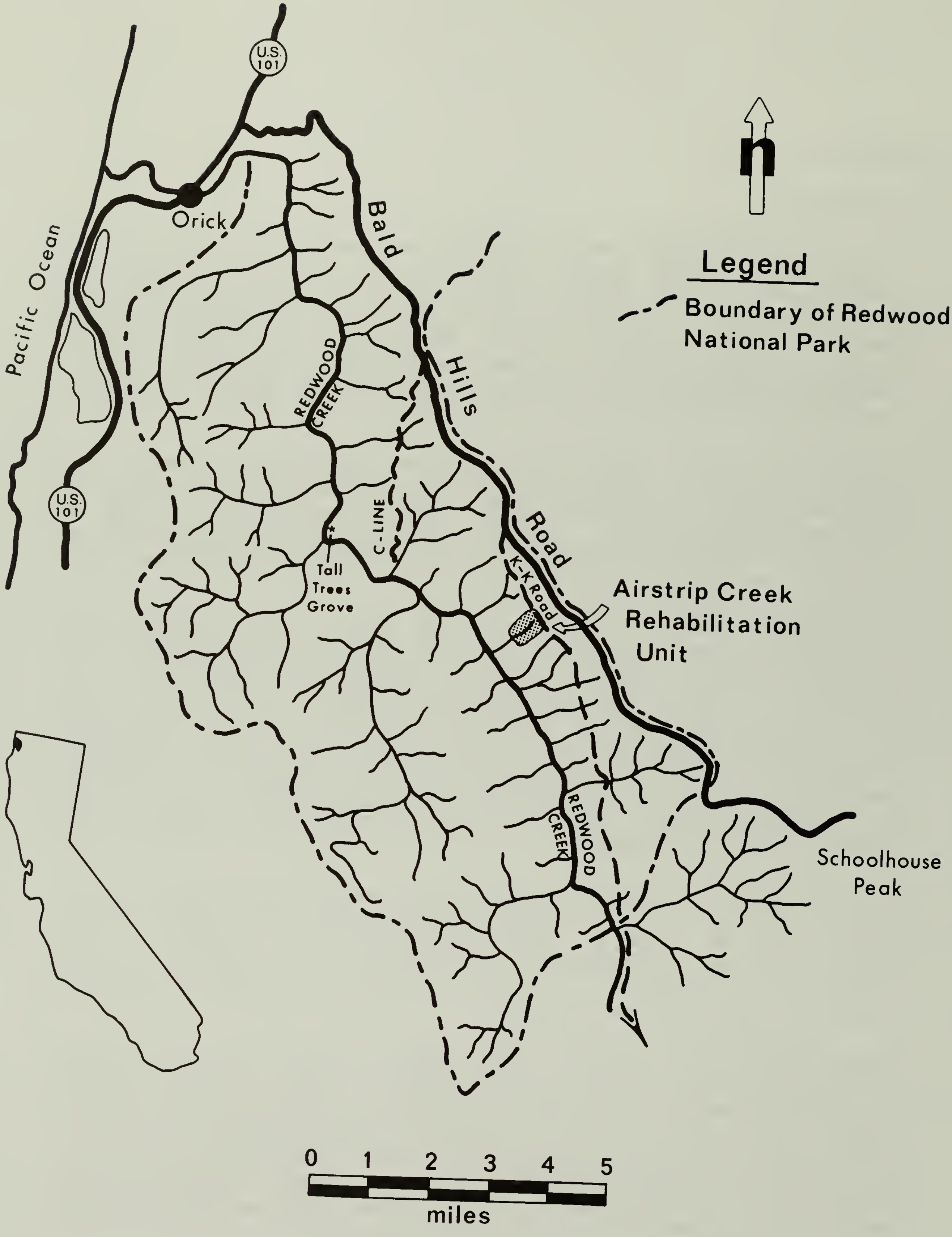


Figure 1

Location of the Airstrip Creek rehabilitation unit within Redwood National Park, Humboldt County, California.

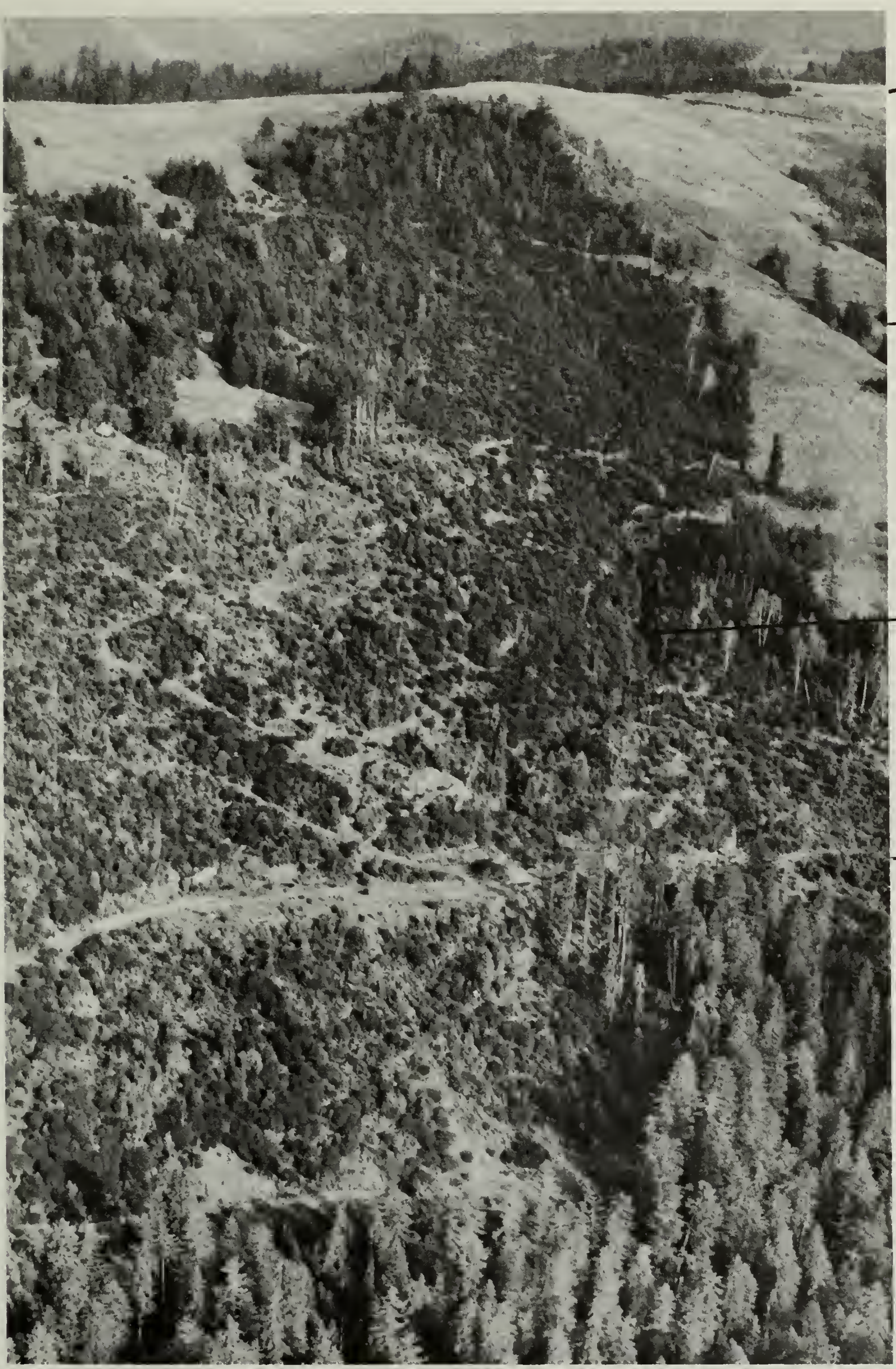


Figure 2

Oblique aerial view of the Airstrip Creek Rehabilitation Unit

B. Contract Selection and Execution of Work

The successful contractor was selected from eight groups that responded to the Request for Proposals. The contract was awarded to the group that was the most responsive to the needs outlined in the Statement of Work, that showed the greatest familiarity with the job site, and that offered the largest amount of work for the proposed price. Total contract price was one consideration in the contract award, but contract award was not based on price alone. Selection criteria included: understanding of problems as demonstrated by the contents and completeness of the proposal and by its technical excellence (55%); qualifications of the individuals to carry out the work proposed (20%); prior experience of the contractor in similar types of work (15%); and reasonableness of cost in terms of work proposed (10%).

The contract was a cost-reimbursable type rather than fixed fee. This means that the contractor charged for his expenses as they occurred and was under no legal obligation to complete the work proposed within the agreed upon contract price. To assure the work was completed within the stipulated price, careful attention to work progress and expenditures was essential on the part of the National Park Service Contracting Officer's Representative (COR). To this end, the Park Service hired a geologist (P. Stroud) whose sole responsibility was to be a field representative for the COR (H. Kelsey) and keep careful track of contract progress.

C. Sequence of Events

Feb. 27, 1979	Start preparation of Request for Proposal (RFP) by park staff.
Mar. 19, 1979	First draft of RFP distributed for in-house park review.
Apr. 16, 1979	Completed RFP sent to National Park Service Western Regional Office for review.
May 29, 1979	Final approved version of RFP received by park staff from National Park Service Western Regional Office.
June 1, 1979	RFP advertised for bid.
June 25, 1979	"Show Me" tour of the rehabilitation site.
July 16, 1979	Bid opening.
July 30, 1979	Contract award.
Aug. 1, 1979	Start work notice.

Aug. 3, 1979	Pre-work conference for National Park Service and contractor.
Aug. 17, 1979	Camp set up at work site.
Aug. 20, 1979	Start phase one (in-channel erosion control work, heavy equipment work).
Sept. 22, 1979	End phase one.
Sept. 25, 1979	Start phase two (channel stabilization and revegetation work).
Oct. 25, 1979	Start winter maintenance work (phase three).
Feb. 1, 1980	End phase two.
May 1, 1980	End of winter maintenance work and end of project.

D. Major Erosion Problems in the Airstrip Creek Unit

The two most significant erosion problems were the diversion of runoff out of natural channels due to road construction, and the erosion of fill (soil, rock, organic debris) placed in stream channels at road and tractor trail crossings. Other erosion problems included streambank cutting where fill was sidecast onto steep streamside slopes and where streamflow was deflected into banks by large organic debris. Hillslope erosion was mainly confined to gullying along tractor trails and rain-splash erosion on steep, unvegetated slopes.

The two forks of Airstrip Creek within the rehabilitation unit were choked with an unnaturally large volume of organic debris, ranging in size from small floatable branches and wood chunks to large dams composed of old-growth logs. The excessive debris loads were due to deliberate placement of logs in channels for temporary tractor crossings and unintentional contributions of organic debris derived from felling and tractor yarding operations.

In the Statement of Work for the Request for Proposal, the offerors were asked to address their work to these problems. The successful offeror, in the opinion of the National Park Service, presented the best set of techniques and proposed work tasks to deal with the erosion problems.

E. Monitoring Program

Monitoring of the contract work by the National Park Service involved pre-work documentation of ground conditions, daily on-site interaction with the contractors during the work phase, and post contract surveys of work effectiveness.

Pre-contract documentation consisted of establishing photo point locations at sites destined to receive erosion control treatment. During the work, the National Park Service kept close track of work progress and provided suggestions and guidance. One of us (Stroud) worked full time during the contract period carrying out the monitoring program and documenting work accomplished and funds expended during the course of the contract work.

After contract work was completed, the photo point locations were reoccupied. In addition, cross sections were established at selected sites where debris was removed from channels. The cross sections provide data on the rates of downcutting in treated stream channels. We inspected the entire unit in August, 1980, to assess the effectiveness of the various erosion control techniques after the first winter season.

Monitoring in the years succeeding August 1980, will be confined to periodically reoccupying photo point locations, resurveying channel cross sections, and assessing revegetative success.

II. TECHNIQUES USED AND TASKS PERFORMED

The work prescribed by the contractor consisted of separate tasks designed to address erosion problems or provide access to these problems. The contractor identified erosion problems at specific work site locations on a schematic map of the rehabilitation unit (Figure 3). The techniques and tasks are itemized below. Phase one work included items A through E, and phase two included items F through N. Additional information on the work tasks can be found in the contractor's final report submitted to the National Park Service (Integrated Forest Management, 1980).

A. Trail System

A trail system consisting of cleared trail and five split wood foot bridges provided access to all work sites. Though not an erosion control task, the trail facilitated access throughout the work area, minimized travel time between sites, and prevented widespread trampling of vegetation. The trail allowed visitor access to the work unit without disrupting erosion control treatments.

B. Waterbars

Hand dug waterbars (drainage troughs for diverting water off gullied roads or tractor trails) were a minor part of contract work. The contractor selected all waterbar locations. In total, 28 waterbars were built or rebuilt from existing tractor constructed waterbars (See Figure 3; Sites 31, 33).

C. Stream Clearance

A major item in the contract work was clearing organic debris of all sizes from both forks of Airstrip Creek. Stream clearance was a separate task from removing debris at stream crossings, which is discussed below. Organic debris dams divert flow into streambanks, causing bank cutting. Debris dams collect sediment, creating the potential for sudden releases of large amounts of sediment if a debris dam fails during high streamflows. Stream clearance was accomplished by hand, using chainsaws and a chainsaw winch for the larger logs. Organic debris was hand carried to locations removed from the stream channel and banks. In this manner, the contractor cleared 4,200 feet of stream channel (Sites 2, 3, 5, 6, 7). Large debris dams and logs well lodged in the channel bed or banks were not disturbed.

D. Heavy Equipment Work Along Lower Road

A major logging haul road, the D-Line, traverses the base of the unit. In an attempt to decompact the roadbed, a D-8 Caterpillar tractor ripped approximately 800 feet of the road to the southeast of the Airstrip Creek crossing at Site 13. Because the tractor did not have ripping teeth, ripping was done using the blade tilted at an angle to the roadbed. With the exception of road fill removed at Site 13, and

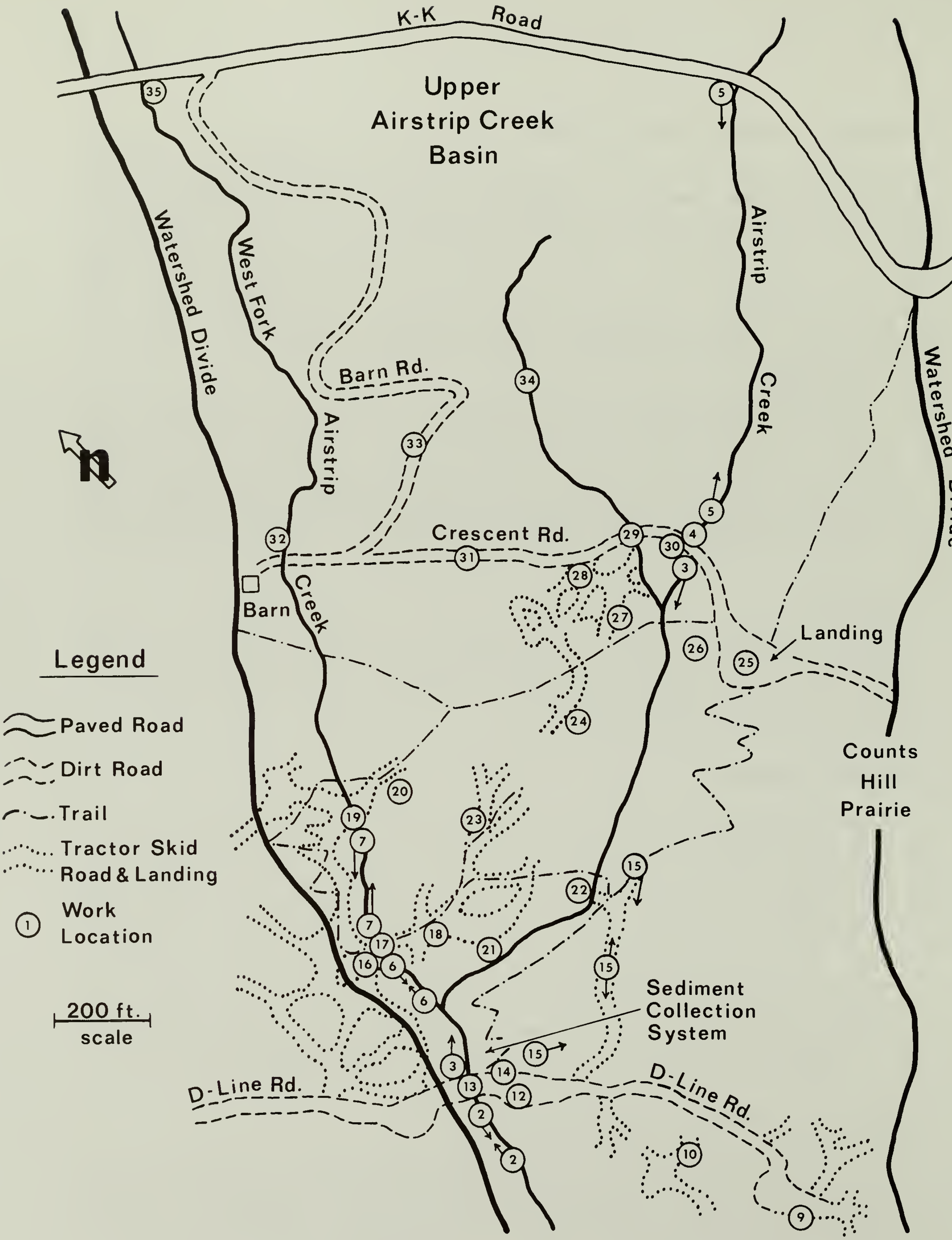


Figure 3

Schematic map of the Airstrip Creek rehabilitation unit showing drainage pattern, road network, and work site locations.

minor fill removal on the road midway between Sites 9 and 13, the fill material that composed the D-Line road bench was left in place.

E. Removal of Debris from Stream Crossings

Debris removal from eight stream crossings was the major task of the contract and the only one which used heavy equipment extensively. At six major tractor crossings (Sites 13, 17, 19, 29, 30, 34), a backhoe excavated the channel to the approximate original channel shape. The contractor rented two different backhoes plus operators for the excavations. The first backhoe was track mounted and did not have an extendable arm on the bucket. It worked for 49.5 hours, or five days, at four tractor crossings. The second backhoe, a rubber tired Case 580-C Extendahoe (Figure 4), worked for 58.0 hours, or seven days, at all six crossings, including the four crossings that were insufficiently excavated by the first backhoe.

In addition to the backhoe work, at two other sites (Sites 21 and 22) fill was pulled off oversteepened channel banks adjacent to roads using a Fresno dragline bucket, which is a chainsaw-pulled two foot by three foot drag bucket that peels back and transports fill upslope as it is guided from behind by a strong individual (Figure 5). Also, a double drum winch operated by a converted automobile engine was used to winch large logs and root wads from one crossing (Sites 4 and 30) where the backhoe was unable to dislodge the large debris.

F. Sediment Collection System

A sediment collection system was installed at the confluence of the two forks of Airstrip Creek (Figure 6). The purpose of the collection system was to capture and divert a portion of the bed load material of the stream and store this material in a collection pond built on a former log landing next to the stream. A D-8 Caterpillar tractor and operator, rented by the contractor, constructed the collection pond. In each fork of Airstrip Creek, a collection box with an adjustable grate captured a portion of the streamflow and bed load material (Figure 7). The water and sediment diverted from each fork travelled down a 200 foot, 12 inch diameter culvert collection pipe into a 205 cubic yard capacity sediment settling pond (Figure 8). A wooden flume conducted the outflow from the pond back into Airstrip Creek.

The sediment collection system operated for the 1979-1980 winter runoff season and was regularly checked and adjusted if necessary during the winter maintenance work. The collection system was dismantled by the contractor in mid-April, 1980, because of the impending end of the contract and the decision by the Park Service not to maintain it.

G. Wattling

Willow wattles were installed at seven separate sites along streambanks where soil had been disturbed during channel excavation (Figure 9). Willow wattles are bundles of willow stems, six feet long and six to

Figure 4

A rubber-tired Caterpillar 580-C backhoe with extendable arm excavated fill from the majority of the stream crossings on the Airstrip Creek rehabilitation unit.

Figure 5

Contractors used a Fresno dragline bucket to drag fill upslope away from an oversteepened streambank adjacent to the East Fork of Airstrip Creek. Site 21. August 23, 1980.

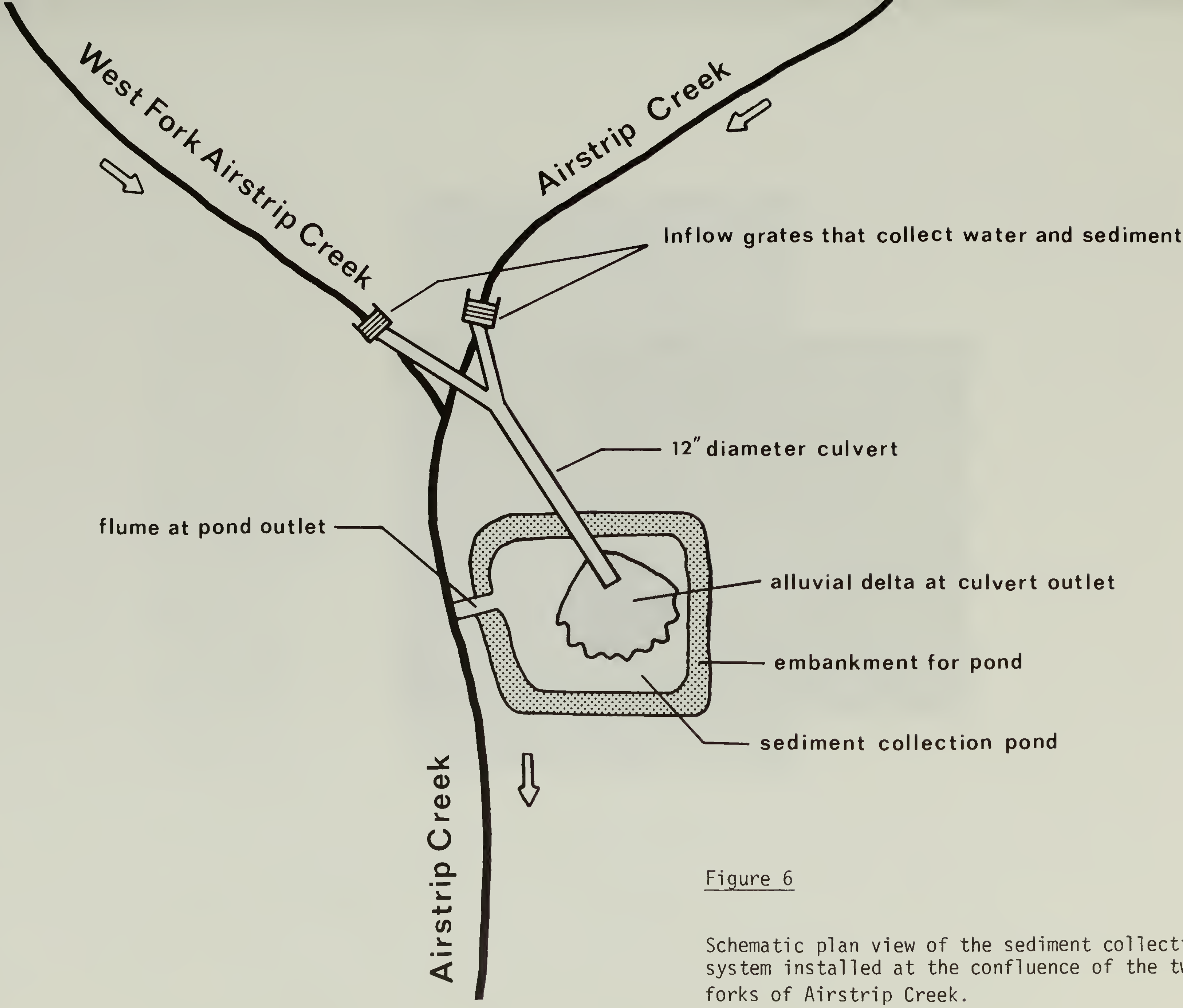


Figure 6

Schematic plan view of the sediment collection system installed at the confluence of the two forks of Airstrip Creek.

Figure 7

Sediment collection box with adjustable grate that controls volume of water and sediment direrted out of the stream and through the 12-inch culvert to the sediment collection pond. West Fork, Airstrip Creek.

Figure 8

Looking up-basin at sediment collection pond in operation. Note the two 12-inch culverts that join to feed water and sediment into the pond. Note also the alluvial delta at the culvert outlet where coarse sediment accumulates. Part of the winter maintenance program included spreading out the accumulated sediment to prevent choking of the culvert outlet. April 4, 1980.

eight inches in diameter. The wattles are place in contour trenches on the slope and covered with soil so that the wattle is just buried. Wattles are staked in place with either redwood or willow stakes. The wattle rows form terraces across the slope, which catch slope ravel and impede the formation of rills. Under favorable conditions, the wattles sprout and help revegetate the slope. Wattling procedures and specifications are described in both Leiser, et al. (1974), and Madej, et al. (1980). A total of 2,146 linear feet of willow wattles were installed.

H. Planter Boxes

Planter boxes consist of split redwood boards placed vertically on the slope and staked in place. The planter boxes are filled with dirt and provide level contour terraces which help establish vegetation and retain slope ravel. Planter boxes were installed on the lower, steeper slopes of the backhoe channel excavations (Sites 21, 29 and 30) where wattling was not practical. Planter boxes were an extremely minor part of the erosion control work.

I. Seeding

The contractor applied grass seed, as an erosion control measure, to approximately 223,000 ft^2 of area laid bare by heavy equipment work (Sites 4, 9 through 23, 26 through 29, 30, and 34). Three different seed mixtures were used for dry, intermediate and wet sites (Appendix 1). Seed was distributed with a cyclone seed spreader at an application rate of 40 pounds per acre. After application, the seed was lightly raked into the soil. All seeded areas were subsequently covered with mulch. The contractor did not apply any fertilizer.

J. Mulching

The contractor hand-spread either straw or a small amount of hay mulch on all seeded areas (Figure 9). The Park Service requested that only straw be used as a mulch because hay contains exotic and perhaps undesirable seeds, and hay rots too quickly to be an effective mulch. In addition, hay is more expensive than straw and not as easy to spread out on the ground. Mulch application rate was two tons per acre. A small 2,700 ft^2 area of skid road between Sites 18 and 23 received a cover of on-site mulch material consisting of cut up coyote bush (Bacharris pilularis) and blueblossom (Ceonothus thrysifolia) branches.

K. Application of Jute Netting

Heavy jute netting, composed of biodegradable hemp, was applied in a single layer on the sideslopes adjacent to the excavated channels and on a few bare tractor trails (Figures 9 and 10). The jute was laid down after the areas were seeded and mulched. Jute netting provides additional protection from rainsplash and rill erosion on steep, bare slopes, and jute helps hold down the mulch. The jute rolls were four feet wide and 225 foot long. The jute was staked in place with eight inch metal staples. The total area covered with jute was approximately 22,500 ft^2.

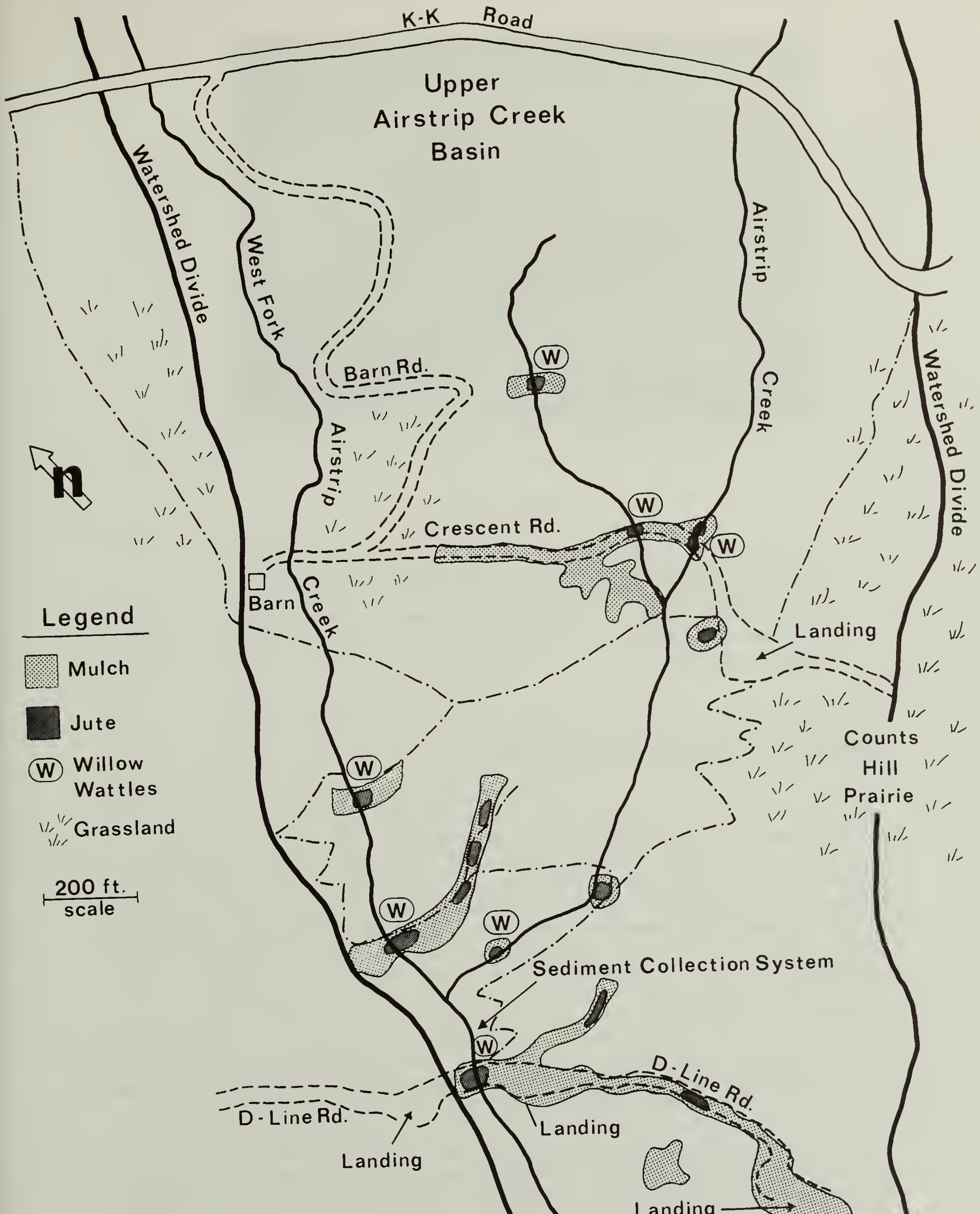


Figure 9

Location of mulch, jute netting and willow wattles on the Airstrip Creek rehabilitation unit.

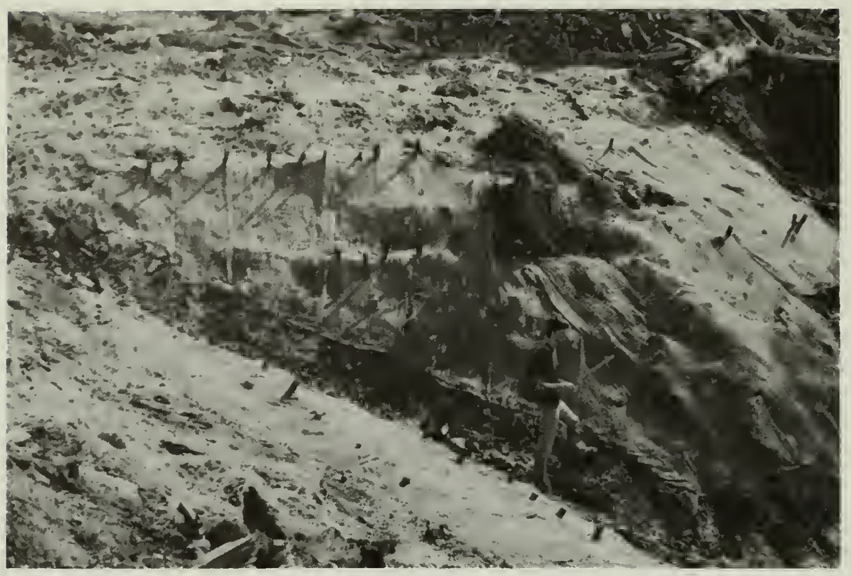


Figure 10

Jute netting stapled down on sideslopes adjacent to excavated stream crossings. The netting was laid on top of ground that had been seeded with grass and mulched with straw. The horizontal wood stakes on the contour hold wattles in place on the slope. Site 19. October 16, 1979.

L. Rocking of Backhoe-Excavated Channels

At four of the six major tractor trail stream crossings, rocks were placed on the channel bed after backhoe excavation. Rock size ranged from four to twenty inches in diameter, with an average size of six to eight inches. The contractor only used rock found in the vicinity of each site, and the rock was hand carried and hand placed. Channel rocking was an extremely small work task compared to the total effort expended on erosion control. We estimate that a total of 60 yd^3-90 yd^3 of rock were placed on the four treated stream crossings.

M. Planting Stem Cuttings

Stem cuttings are gathered from live sprouting plant species. At Airstrip Creek, the cuttings were cut approximately 12 inches long and were set in the ground so that two-thirds of their length was buried.

The contractor planted stem cuttings two to three feet apart at sites of soil disturbance caused by the heavy equipment work (Sites 4, 9 through 21, 31, 34, and 35). Planting was done in the fall and winter after rain storms had softened the soil so that the cuttings could be driven into the ground without breaking.

The contractor used different species of stem cuttings for dry, intermediate and moist sites. On dry and intermediate sites, which comprised approximately 90% of the planted area, cuttings consisted of Sitka willow (Sitka sitchensis), coyote bush (Baccharis pilularis), and yerba de selva (Whipplea modesta). In moist areas near the stream channels, thimbleberry (Rubus parviflorus), elderberry (Sambucus sp.) and salmonberry (Rubus spectabilis) were planted in addition to willow. The contractor collected all stem cuttings from Redwood National Park lands near the work site. The total area planted was 105,600 ft^2 and the total number of cuttings planted was 17,613, giving a density of one cutting per six square feet. Relative proportions of each species were: willow, 34%; coyote bush, 32%; yerba de selva, 30%; thimbleberry, 1%; elderberry, 1%; and salmonberry, 1%. The contractor's final report, (Integrated Forest Management, 1980), on file at Redwood National Park, includes data on species type and number of stem cuttings planted at each work site.

N. Winter Maintenance

The Airstrip Creek rehabilitation unit Request for Proposal called for a winter maintenance program to be carried out from the first fall storm of 1979 through April 30, 1980. The purpose of winter maintenance was to inspect the work sites and erosion control measures and correct any problems.

The RFP requested that winter maintenance be concentrated during storm periods, especially the first major storms of the season when the erosion control work would be initially tested. In addition, maintenance crews were to be on-site during or immediately after each large storm for the duration of the winter season.

Winter maintenance work included draining ponded water from roads and landings. Excavated channels were inspected and downcutting or lateral cutting during high storm flows was minimized by rocking, removing debris, armoring banks, and improving energy dissipation structures. Maintenance also involved cleaning out or extending waterbars when necessary, maintaining the trail network and relocating the trail around especially steep or wet areas. Vegetation work was inspected and, if necessary, wattles were reinforced on the steeper slopes with more stakes, and areas were reseeded and raked where seed may have been washed away. In addition, a major task during winter maintenance was inspecting and operating the sediment collection system during storm periods. Sediment collection system maintenance involved adjusting the openings on the inflow grates at each fork of Airstrip Creek to make sure water flowing into the pond did not exceed discharge capacity of the flume at the pond outflow. The maintenance crews periodically spread out sediment concentrated in the alluvial delta at the culvert outlet to the pond so that the pond would fill evenly and the outlet would not become plugged.

III. PROJECT COSTS

Work project costs are reported in person hours per work task. The hourly wage for all employees of Integrated Forest Management was $8.50. Including employer's payroll taxes, liability taxes, and bookkeeping overhead, the total wage rate charged to the U.S. Government was $13.25 per hour. The reported person hours for each project are labor hours at the site. Work project hours do not include costs for vehicles, pack animals, depreciation on tools, camping supplies, heavy equipment rental or commercial hauling.

The average size of the contractor's work crew was 12 people during phase one of the work. Work crew size was highly variable during phase two work, but never more than 12 persons.

Tables 1 and 2 show person hours and work quantities, or work products, for both phase one and phase two. The data on person hours comes from three sources: (1) daily work reports, kept by the Park Service field coordinator of the project (P. Stroud), (2) data presented in graphical form in the contractor's final report (Integrated Forest Management, 1980), and (3) a summary of project hours per task presented by the contractor in their final report. The three sources did not always agree but sources (1) and (2) were always similar, and the data relies heavily on these sources. Table 3 shows monthly person hours devoted to phase three of the contract, winter maintenance.

Total project costs (Table 4) include both contract costs and government expenses. Total contract costs are about three times greater than the contractor's on-site labor costs for the work tasks. Total contract costs better reflect the true expense of labor services under a cost-reimbursable contract because the contractor charges for all logistical and administrative needs of the contract separately from the labor costs. Government costs include salary expense for time devoted to contract supervision and documentation. The contractor received 87% of the total project cost, and salaries of Government employees who supervised or administered the contract account for the other 13% (Table 4).

TABLE 1

ON-SITE LABOR COSTS AND WORK PRODUCTS FOR PHASE ONE EROSION CONTROL WORK

AIRSTRIP CREEK REHABILITATION PROJECT

WORK TASK	PERSON HOURS	EQUIVALENT COST AT $13.25/HOUR	WORK QUANTITY OR WORK PRODUCT
Trail System	180	$ 2,385.00	3,500 feet of trail, mostly on tractor roads.
Waterbars	90	$ 1,192.00	28 waterbars.
Stream Clearance	430	$ 5,697.50	4,200 feet of stream channel.
Removal of Debris from Stream Crossings[1]			
Hand Operated Fresno Dragline Bucket[2]	100	$ 1,325.00	Removal of 2 oversteepened channel sideslopes.
Backhoe Work, Cost of Supervision by Contractor [3]	125	$ 1,656.25	Excavation at 6 stream crossings.
Double Drum Winch[4]	50	$ 662.50	Removal of logs at 1 of the 6 stream crossings.
T O T A L	1,393	$ 18,456.75	

Notes:

1. We were not able to measure the volume of debris removed by the backhoe, Fresno bucket, or double winch because of lack of data on channel sideslope configuration prior to excavation. However, backhoe channel excavations were on the order of 125 yd^3 to 160 yd^3 per crossing.
2. Rental of Fresno dragline bucket was an additional $45.00.
3. Rental of backhoe and opertor used to remove debris cost an additional $4,145.00.
4. Rental of double drum winch was an additional $284.00.

TABLE 2

ON-SITE LABOR COSTS AND WORK QUANTITIES FOR PHASE TWO CHANNEL STABILIZATION AND REVEGETATION WORK
AIRSTRIP CREEK REHABILITATION PROJECT

Work Task	Person Hours	Equivalent Cost at $13.25/Hour	Work Quantity
Wattling: Preparation and Installation	290	$ 3,842.50	2,145 linear feet.
Rocking of Backhoe-Excavated Channels	12	159.00	60 yd^3 - 90 yd^3 of rock.
Installing Planter Boxes	15	198.75	30 linear feet of boxes.
Seeding and Mulching Bare Slope Areas	130	1,722.50	223,000 ft^2 (5.12 acres).
Laying Out Jute Netting	100	1,325.00	22,500 ft^2.
Stem Cuttings: Preparation and Planting	300	3,975.00	17,613 cuttings.
T O T A L	847	$11,222.75	

TABLE 3

ON-SITE LABOR COSTS PER MONTH
FOR THE WINTER MAINTENANCE PROGRAM (PHASE THREE)
AIRSTRIP CREEK REHABILITATION PROJECT

Month That Winter Maintenance Was Performed	Person Hours	Equivalent Cost at $13.25/Hour
October	137.5	$ 1,821.88
November	60.0	795.00
December	14.0	185.50
January	14.0	185.50
February	35.0	463.75
March	17.0	225.25
April	12.0	159.00
T O T A L	289.5	$ 3,835.88

TABLE 4

TOTAL PROJECT COSTS FOR THE AIRSTRIP CREEK REHABILITATION PROJECT

Labor Hours - Includes on-site labor cost plus administrative, cooking, and all other salary expenses	$61,566.10	
Camp Costs - Lodging	921.16	
Camp Costs - Food	2,378.81	
Contract Supplies	5,878.31	
Vehicle Mileage	1,763.41	
Fuel for Vehicles and Power Tools	929.56	
Heavy Equipment Rental Including Transportation[1]	4,928.50	
Rental of Hand Tools, Winches, Chainsaws	2,723.00	
Commercial Hauling and Shipping of Materials	430.93	
Miscellaneous	242.80	
Administration Expenses Exclusive of Salary	717.59	
TOTAL PAID TO CONTRACTOR AS REIMBURSEMENT FOR CHARGES SUBMITTED	$82,855.62	
10% FIXED FEE FOR PROFIT ALLOWED TO CONTRACTOR UNDER CONTRACT STIPULATIONS	8,285.56	
TOTAL PAID TO CONTRACTOR	$91,141.18	$ 91,141.18
Government Salary Expense For:		
Contracting Officer	$ 1,030.00	
Contracting Officer's Representative (COR)	4,700.00	
COR's Field Representative	6,200.00	
Members of Contract Selection Review Team	875.00	
Other Government Expenses:		
Vehicle Mileage	675.00	
Consultation with Other Park Staff	700.00	
TOTAL GOVERNMENT EXPENSE, EXCLUSIVE OF PROCESSING PAYMENTS	$14,180.00	$ 14,180.00
TOTAL PROJECT COST		$105,321.18

1. Cost Breakdown for Heavy Equipment:

a. D-8 Caterpillar Tractor	- $70/Hour for 4.5 Hours	$ 315.00
	- Flagtime	25.00
	- Hauling	443.50
b. Track-Mounted Backhoe	- $40/Hour for 49.5 Hours	1,980.00
c. Case 580-C Backhoe	- $35/Hour for 58 Hours	2,030.00
	- Hauling	135.00
	TOTAL	$ 4,928.50

IV. EVALUATION OF THE MAJOR ASPECTS OF THE EROSION CONTROL WORK

A. Trail System

A trail system is desirable to convey persons, equipment and materials to work sites by the most efficient and least damaging routes. Carefully laid out and well marked trails are worth the effort if repeated access to the work site is necessary and if a variety of different individuals and groups will be working or visiting at the site. A well planned trail system is especially useful to avoid erosion if the site will be visited repeatedly in the winter rainy months.

The trail system at the Airstrip Creek rehabilitation unit was well laid out, well marked, and provided efficient access to all work sites. The five split redwood foot bridges provided easy travel over rough terrain. The trail system remained useable in wet weather, though it did traverse some unavoidable soggy areas.

Because visitation to the unit dropped off to virtually zero after the completion of the contract, we think that sections of trail could have been constructed at less expense by reducing the amount of brush clearing and constructing simpler foot bridges. In general, an integrated, planned trail system, while not an absolutely necessary component of erosion control work, provides efficient and easy-to-follow access to work sites for both workers and visitors.

B. Stream Clearance

The contractor cleared a total of 4,200 feet of stream channel along the two forks of Airstrip Creek within the rehabilitation unit (Figure 11). Stream clearance was concentrated in the lower portion of the unit where the two forks flow through the more recently logged hillslopes. Airstrip Creek in this part of the basin is an intermittent stream, and clearance work was completed in the fall before the channel started to carry water from the winter rains.

Stream clearance work performed by the contractor was classified into four categories: (1) removal of small, loose, floatable organic debris (small branches, chunks of wood, pieces of bark) from the channel bed; (2) removal of large, loose organic debris that required cutting up logs before removal by hand; (3) removal of log dams; and (4) partial removal of keyed logs by cutting off the logs above the point where they protrude out from the channel bed or banks, and notching of partially buried logs in the channel bed. Figure 12 documents changes that occurred along the creek channel at Site 2 where the contractor carried out all four of the stream clearance methods described above.

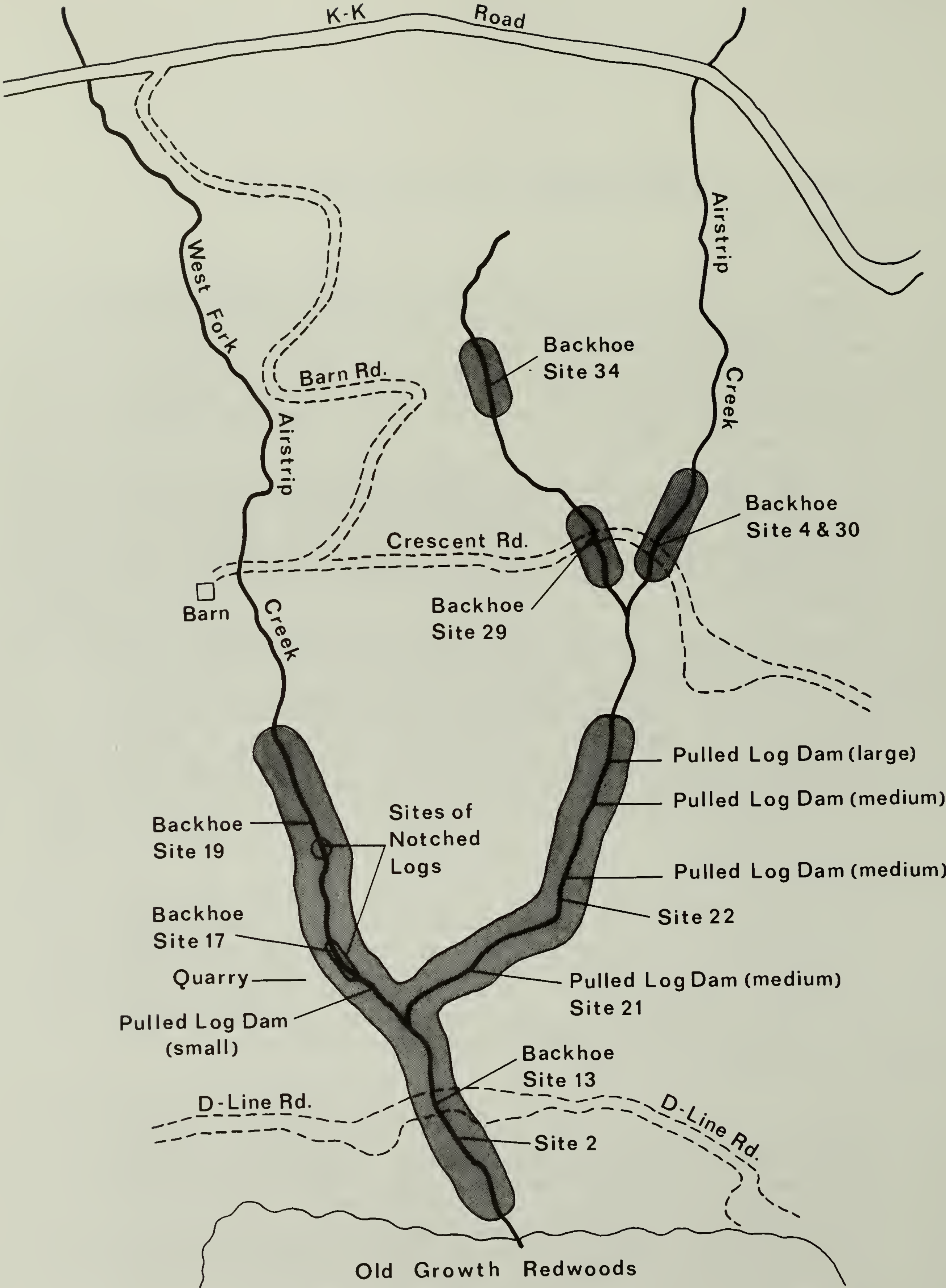
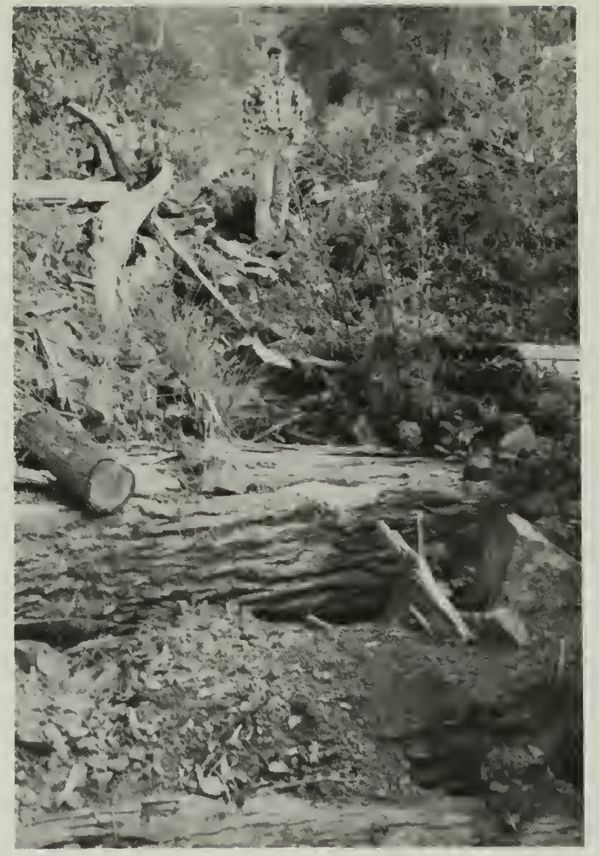


FIGURE 11

Location map of stream clearance sites and backhoe channel excavation sites. Airstrip Creek rehabilitation unit.

12A



12B

12C

FIGURE 12

Photo sequence showing results of hand clearing organic debris from Airstrip Creek in channel reach approximately 30 feet below D-Line Crossing (Site 2).

A. August 14, 1979: Pre-stream clearance.

B. October 16, 1979: After stream clearance before winter rainy season, loose sediment formerly trapped behind organic debris is now ready for immediate downstream transport.

C. May 6, 1980: After 1979 - 1980 winter rainy season, all the finer-grained, loose sediment in the foreground of Photo B is now gone.

A series of storm events from mid-October through November caused obvious changes in the channel configurataion of both forks of Airstrip Creek where organic debris was removed. Total rainfall from these storms was 23.5 inches at a nearby precipitation gage (0.35 miles to the northwest) and precipitation intensities for two off the storms exceeded 2.5 and 4.0 inches in a 24-hour period. Consequently, streamflow response was rapid and substantial. Effects of these storms allow an appraisal of the different types of debris removal.

After the early winter storms, stream channels contained the same amount and type of small, loose organic debris that was in the channel prior to removal. There appears to be a continual contribution of this small debris and its removal produces only a temporary change. Removal of small debris is not necessary and it may be advantageous to leave this type of debris which tends to form small, natural check dams that help control downcutting.

Removal of large, loose organic debris that must be cut up before being carried out of the channel can be an effective erosion prevention measure. These larger logs can be transported downstream to points where they become lodged and start to form a log dam or deflect streamflow into erodable banks.

One large and several smaller log dams were removed from Airstrip Creek (Figure 13). Sediment trapped behind these log dams began to erode during high streamflows generated by early winter storms. As this sediment moves downstream, previously buried debris is smaller than the main components of the original log dam. In any case, log dam removal resulted in uncovering buried organic debris that is now, once again, determining local channel configuration and gradient.

In intermittent streams like Airstrip Creek where tractor yarding contributed large volumes of organic debris to channels, log dam removal may be similar to cutting off an iceberg at sea level in an attempt to get rid of it - more of it soon becomes exposed. In addition, by removing a dam intentionally during rehabilitation, loose sediment trapped behind the dam is rapidly transported downstream only to be stored behind other debris barriers. In the case of Airstrip Creek log dam removal, it is unclear if any benefits were gained because the dam removal released sediment trapped behind the dam and exposed more large organic debris that could form new dams, new obstacles or deflect streamflow.

At several locations along both stream reaches, the contractor either cut off and removed protruding portions of logs or cut large spillway notches in other logs partially buried in the channel bed. Before cutting off protruding logs, the contractor paid careful attention to the streamflow pattern to determine

FIGURE 13

Photo showing work in progress on the removal of logs not buried by sediment in a medium-sized log jam above Site 22. September, 1979.

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deflection points and identify areas that might collect organic debris and form log dams. Ends of keyed logs were removed to open up and better define the channel without removing the entire log and disturbing the stream banks. In five areas, the middle of partially buried logs that crossed the stream channel were notched or removed. Water now flows through these opened up areas, stream deflection to channel banks by organic debris has been minimized, and the stream has a more defined path to follow. This technique relies heavily on the judgment of the worker using the chainsaw. Workers on the Airstrip Creek Project had a good understanding of erosion processes in small streams and these techniques were effective in opening up and better defining a channel through reaches with high amounts of organic debris.

C. Heavy Equipment Work Along the Lower Road

Heavy equipment work along the lower road to the southeast of Site 13 was limited to ripping the roadbed with a Caterpillar tractor and excavating one minor drainage crossing with the backhoe. The road bench was not outsloped and no fill was removed from the outer edge of the road. During the winter, a 25-foot long portion of the road bench started to slump downslope onto a flat piece of ground below. The slump scarp was about 15 inches high in August, 1980. Expensive heavy equipment work may have prevented the slumping by physically removing the unstable perched fill. However, the slump is not going to directly deliver sediment to a stream course and the slump mass will eventually stabilize and revegetate. The limited heavy equipment work on the lower road would have been more effective if a Caterpillar tractor with hydraulic ripping teeth had decompacted the road. However, in retrospect, we do not feel a more thorough treatment of the perched fill in the roadbed was merited, despite the slumping.

D. Removal of Debris From Stream Crossings - Effectiveness of Heavy Equipment Work and Channel Rocking

Debris removal from the six major tractor road stream crossings (Figure 11) was the single most effective rehabilitation measure in terms of minimizing the chances for continued severe erosion due to past logging disturbance. Prior to rehabilitation, fills in all crossings were partially eroded. Although the fills were partially vegetated, they had steep sided gullies with bare banks that were a sediment source at high streamflows. Most of the fills contained large logs, and water piped through the fills at low flows.

Prior to excavation, the backhoe had to temporarily fill in the channel in order to cross it to start work. At each site, a backhoe excavated a new channel that was similar to the original channel profile and original channel sideslopes prior to logging. The end product was an excavated channel with moderate slopes and less sediment perched above the stream.

Channel excavation results in less sediment contribution in the long run because fill is removed to stable areas away from the streambank. However, in the short run, increased sediment yield from the site can be expected as channel beds adjust and slopes revegetate following disturbance during excavation. Short-term erosion can occur by channel downcutting and widening as well as by rainsplash and rill erosion on the adjacent sideslopes.

Initial results of channel debris removal at the six major sites provides insight into the advantages and potential problems of such work. At all the sites, the backhoe excavated channel resembles the pre-logging channel and the moderate sloping channel banks are better suited for revegetation and less prone to slumping. In addition, unstable fill is no longer perched within the channel where it could be flushed downstream, as a mass, by infrequent flood flows.

A track mounted backhoe excavated most of the fill at the three upper channel sites (Sites 29, 30 and 34). Because the track-mounted backhoe could not excavate deep enough to reach the probable original channel profile, a rubber tired backhoe refined the work at these sites. The track mounted backhoe was less maneuverable than the rubber tired backhoe and did not have an extendable arm. Consequently, major downcutting (greater than three feet) occurred at the downstream end of each of the crossings where the track mounted backhoe could not reach. Rubber tired backhoes, with a hydraulically extendable arm, should be used for removal of fill from channels the size of Airstrip Creek (Figure 14 shows average channel cross section size).

Downcutting after the onset of winter flows occurred in all channels. Figure 14 shows the extent of channel downcutting at representative cross sections of three excavation sites. The majority of downcutting occurred during the first three major storms (October 19, 1979 to November 30, 1979). During the remainder of the winter, downcutting decreased despite equally large storms later in the season. Although all the excavated channels except the uppermost (Site 34) and lowermost (Site 13) were hand rocked to prevent downcutting, the rock was too small (five to ten inches in size) and was transported downstream during storm events (Figures 15 and 16, Sites 29 and 30). At Site 17, near a quarry, the contractor carried large rocks to the site (sizes ranged from six inches to thirty inches; average size was twelve inches). These larger rocks effectively prevented downcutting only after they were moved by high streamflows and redeposited in a more stable channel bed configuration that developed following downcutting (Figure 17). Large rock placed in the channel did not prevent downcutting in cases where the channel excavation was not deep enough, the rock was not properly placed, and the rock cover did not completely blanket the channel bed.

In all cases, the greatest downcutting occurred at the downstream end of the excavated channel where the backhoe left a break-in-slope between the excavated channel and the undisturbed channel below. Downcutting was most pronounced where the excavated channel profile was distinctly convex at this slope break (Figure 18, Site 17). At two sites (Sites 13 and 30), where downcutting at the break-in-slope would otherwise have been severe, large chunks of organic debris formed a stable step in the channel that prevented erosin at the slope break. Organic debris also prevented plunge pool erosion below the step. Even a channel bed with negligible rocking (Site 13) did not significantly downcut where there was a stable organic debris step at the lower end of the excavated channel (Figure 19, Site 13).

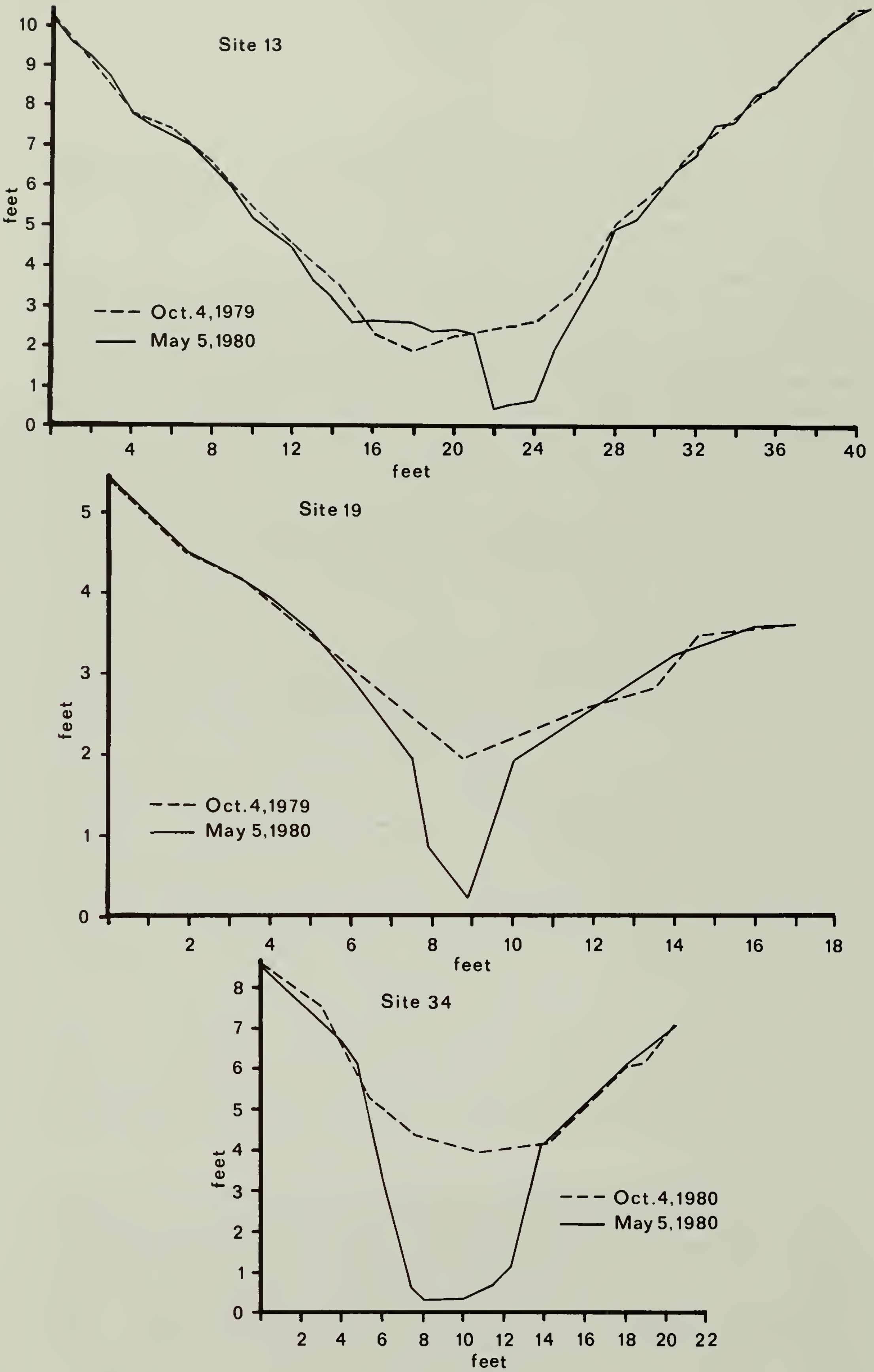

FIGURE 14

Surveyed channel cross sections at three sites of heavy equipment excavation of fill from stream crossings showing the amount of channel downcutting during the 1979-1980 winter season. The profiles are exaggerated vertically two times.

FIGURE 15A

FIGURE 15B

FIGURE 15C

FIGURE 15

Three consecutive photos of Airstrip Creek channel at Site 29:

FIGURE 15A - August 14, 1979 - Prior to heavy equipment excavation.

FIGURE 15B - October 16, 1979 - After backhoe work, hand-placement of rock in the channel and seeding, mulching and installation of jute, but before winter rains.

FIGURE 15C - May 6, 1980 - After winter rainy season, showing that hand-placed rock has been carried downstream and channel banks are undercut.

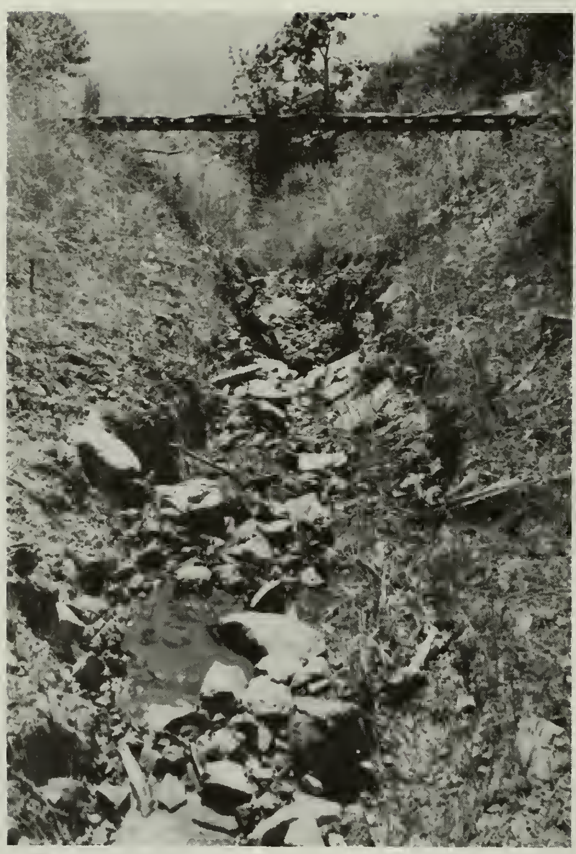

FIGURE 16

The excavated channel had been blanketed with a layer of hand-placed, four inch to ten inch rock prior to the 1980 winter rainy season. Winter storm flows were capable of transporting all the hand-placed rock. More than two feet of downcutting took place before a stable channel configuration became established. Site 30. July 25, 1980.

FIGURE 17

Despite the size of these hand placed rocks in the channel at Site 17 (note the small backpack for scale), approximately two feet of downcutting occurred due to incomplete excavation of the channel. Another cause of downcutting may be that the rock blanket did not totally cover the streambed.

FIGURE 18A

FIGURE 18B

FIGURE 18C

FIGURE 18

Airstrip Creek channel at Site 18:

FIGURE 18A - August 14, 1979 - Channel prior to heavy equipment work.

FIGURE 18B - October 16, 1979 - Channel and sideslopes after backhoe and hand labor rehabilitation work was finished but before winter rains. Note the distinctive break-in-slope of the channel gradient just upstream of the man.

FIGURE 18C - May 6, 1980 - After the winter rainy period, obvious downcutting in the channel above the protruding stump on the right bank of the channel occurred.

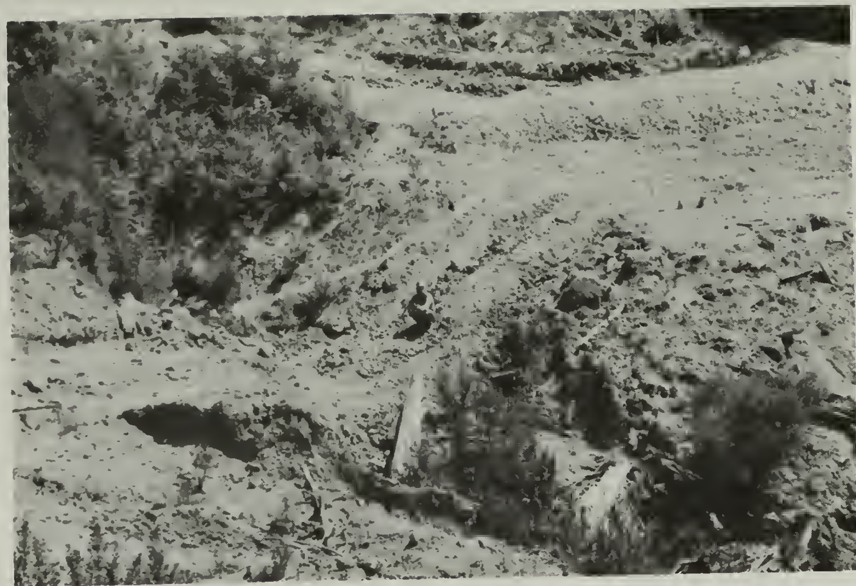

FIGURE 19A

FIGURE 19B

FIGURE 19C

FIGURE 19

Airstrip Creek channel at Site 13, the former crossing of the D-Line, a major logging haul road. The channel at this site was not rocked after excavation, but downcutting was not severe (see Figure 13) because the excavation was deep and large organic debris in the channel at the break-in-slope at the lower end prevented downcutting.

FIGURE 19A - August 14, 1979 - Prior to heavy equipment work, except for a couple of crossings by a D-8 Caterpillar tractor.

FIGURE 19B - October 16, 1979 - After heavy equipment and hand labor work, but before winter rains.

FIGURE 19C - May 6, 1980 - Condition of the channel after the winter rainy season.

The degree of downcutting was noticeably influenced by the presence of organic debris in the channel bed. In excavated reaches where the channel material contained a significant amount of sticks, small boughs, chunks of bark, parts of roots, or a few logs, the channel stabilized after initial downcutting. A series of stable organic debris steps were created by sand and gravel piling up behind and on top of the woody debris and anchored it in place. Excavated channels devoid of organic debris in the bed material downcut much deeper. At one site, downcutting proceeded well into the sheared, weathered bedrock that was below the pre-logging channel elevation. At any site with a steep gradient, floatable organic debris becomes dislodged and transported, and only keyed-in logs and root wads significantly impede downcutting. However, keyed-in logs and root wads also can deflect flow into unstable banks, so effective erosion control by organic debris depends on its position.

Documentation of the magnitude of post-excavation downcutting at these channel sites would have been more thorough if we had surveyed longitudinal profiles of the channels after heavy equipment work but prior to winter streamflows. However, despite the lack of such surveys, observations clearly indicate that to minimize downcutting, channels should be excavated as near as possible to original channel gradient and rock, if used, must be larger than the size the stream is able to transport, or rocking becomes a waste of effort.

Hand placing rock in excavated channels was an extremely small work item in the Airstrip Creek contract (Table 2). Considering the potential benefits of placing large rock in channels to prevent downcutting, the contractor should have expended much more effort to thoroughly rock the excavated channel beds with the largest rocks available. Additional backhoe time could have been profitably utilized to haul large rock to crossings near the quarry

An alternative to channel rocking is constructing a series of board checkdams, which prevent downcutting regardless of whether complete excavation to original channel gradient occurred. Board checkdams are highly effective if properly placed and properly constructed, but they are more expensive per channel foot than rocking (Madej et al., 1980).

E. Sediment Collection System

The sediment collection system was installed at the contractor's initiative as part of the proposal accepted by the Park Service. The Park Service believed valuable information would result from building the system and watching its performance. Unfortunately, only a limited evaluation of the sediment system is possible because we do not know the average annual sediment load of Airstrip Creek in the post logging period at the site of the collection pond.

The sediment collection system performed as expected. With the slots on the inflow grates opened two to four inches, water and bedload material fell into the collection box and flowed through the 12-inch culvert to the collection pond, where the bedload material settled in an alluvial delta at the culvert outlet. The alluvial fill at the culvert outlet had to be periodically spread to allow free discharge of sediment from the culvert. Figure 20 shows a photo sequence of changes at the sediment collection pond from August, 1979, through May, 1980.

The alluvial material collected in the sediment pond during the course of the winter was approximately 105 yd^3, or 51% of the estimated pond capacity. The impounded sediment undoubtedly represents only a fraction of the total annual bedload material of Airstrip Creek at the point of sediment collection. In addition, the amount of material collected in the pond was small compared to the channel area of the 3,600 foot reach of Airstrip Creek (all in old-growth forest) between the collection pond and the confluence with Redwood Creek. If all the sediment does not course through the channel in one event, it may not contribute to accelerated erosion. However, this amount of sediment is large enough to influence channel form, especially if concentrated behind organic debris in the channel.

Because the sediment collection system was expensive ($7,500) and required constant winter maintenance which further increased the cost, we feel the sediment system did not afford sufficient short-term or long-term benefits to the rehabilitation of the Airstrip Creek basin. Similar systems will probably not become a regular feature of rehabilitation programs at other sites within Redwood National Park. However, the system did perform well and is a good design for use in similar sized watersheds where diversion of a portion of the bed load out of the active channel is the specific goal of a project.

F. <u>Winter Maintenance</u>

Winter maintenance work during storm runoff periods is essential to ensure optimum functioning of erosion control structures installed during the dry season. A few hours spent hand shoveling ditches or waterbars can prevent washout of costly erosion control work along tractor roads or near stream crossings.

The most important element in a successful maintenance program is being on site during the first three to five major storm periods. The contractor was generally present at such times and therefore could perform needed modifications and repairs. Operation and adjustment of the sediment collection system was a major component of the maintenance program on the Airstrip Creek unit.

FIGURE 20A

FIGURE 20B

FIGURE 20C

FIGURE 20

Three sequential photos showing the sediment collection pond on a log landing of the D-Line Road adjacent to Site 13:

FIGURE 20A - August 14, 1979 - The pond immediately after it was built by a D-8 Caterpillar tractor before the winter rainy season.

FIGURE 20B - April 4, 1980 - The pond near the end of the ronoff season just before the sediment collection system was removed by the contractor. The alluvial delta is broad and flat because sediment was periodically spread out manually during winter maintenance.

FIGURE 20C - May 6, 1980 - Appearance of the pond after removal of the sediment collection system before water had totally evaporated.

Rapid downcutting at most excavated stream crossings occurred during the first few major storm events after the ground became thoroughly wetted. Winter maintenance work cannot prevent such rapid, storm induced downcutting, even if maintenance crews are on site. Therefore, winter maintenance work, even if well performed, will not make up for incomplete channel excavations or inadequate channel rocking.

The winter maintenance work was cost effective (Table 3) as an insurance against localized severe gullying on recently treated work sites and for the purpose of operating the sediment collection system. Maintenance can be performed less frequently as the winter progresses and the erosion control work has been tested. However, maintenance crews should be on site for any long-duration, high intensity storm, regardless of how late such a storm occurs in the winter season.

G. Straw Mulch and Jute Netting for Erosion Control

On sideslopes of excavated stream crossings, the contractors used straw covered by jute netting as a ground cover for erosion control (Figure 9). This combination of straw mulch and jute net provided extremely effective slope protection against both raindrop impact erosion and rilling. The straw-jute net cover kept fine soil particles in place on the surface, preventing the formation of a compact surface crust and pebble pedestals that characteristically result from high intensity rain falling on bare, recently disturbed soil. The preservation of a loose, open framework soil surface, plus the retention of moisture beneath the mulch, may aid in revegetation.

The jute netting is an important element of this slope cover mainly because it effectively holds the straw in place. Neither the jute alone, nor just the straw at two tons per acre, would provide sufficient cover. Jute netting is expensive to install. At Airstrip Creek, the labor cost of installation was $58.89 per 1,000 square feet of ground surface (Table 2). The jute net-straw ground cover is therefore highly effective, but also costly. The combination should be used only in areas where raindrop impact erosion and/or rilling are likely to cause large amounts of on-site erosion, or where jute is the only treatment that will hold straw in place. A less expensive technique may be to eliminate the jute netting and increase the straw application rate to three tons per acre.

We never checked to ensure that the straw application rate was indeed two tons per acre so we are uncertain if the straw cover was as thick as stated by the contractor. Field inspection of straw cover installed by the Park Service in other areas where the application rate was carefully documented suggests that the straw cover at Airstrip Creek was at most two tons per acre, and probably less.

H. Revegetation Work

Revegetation work has not been surveyed by Park Service personnel. A revegetation evaluation for the Airstrip site is forthcoming; however, a few comments are appropriate. Recent evaluation of revegetation work on 1978 rehabilitation sites within the park (Reed and Hektner, 1981) showed that willow wattles and willow stem cuttings were not successful at most locations due to lack of moisture, exacerbated by heavy deer and elk browsing. We are seeing the same results at Airstrip Creek at many sites. Given the extremely high cost of this work item (Table 2), we feel the benefits of using willow on the Airstrip site may be negligible. At the stream crossings, a grass seed mixture was spread prior to laying down the straw and jute net cover, and at least one species of grass grew profusely during the first winter. However, as an erosion control technique, the grass seed was unnecessary because the straw and jute net cover alone held the fine, surface soil particles in place.

Stem cuttings are the other high cost item of the revegetation work. Their success will become apparent only after the forthcoming revegetation survey.

V. QUALITATIVE APPRAISAL OF THE COST EFFECTIVENESS OF CONTRACT WORK

The Airstrip contract was cost reimbursable, thus the contractor charged the Park Service for every expense incurred while on the job. Also, the contract entitled the contractor to a fixed fee of ten percent for profit. A cost-reimbursable contract was justified at the time of contract preparation (February 1979) because the work was unconventional and erosion control costs were unknown. However, this work is no longer totally novel and cost data is now available (Madej, et al., 1980; Weaver and Madej, 1981). The cost reimbursable nature of the contract made it expensive and we do not recommend using this procedure for similar work in the future.

The Request for Proposal (RFP) type of contract solicitation is a viable alternative to formally advertised contracts, but the contract award should be for a specified product at a fixed price. The Park Service awarded a fixed price RFP contract in Devils Creek for the 1980 - 1981 rehabilitation season. RFP contracts allow for initiative by local erosion control contractors and can result in innovative work. Innovation by contractors is less likely in a formally advertised contract where the Park Service specifies for all work tasks.

Table 5 summarizes expenses on the Airstrip Creek erosion control contract and shows how much money went to on-site labor and heavy equipment work compared to labor and other costs not directly involved with on-site work. The high cost of off-site labor and logistics in part reflect the cost-reimbursable payment process where the contractor did not have to absorb any costs at the expense of salary or profit.

Direct labor costs and heavy equipment costs (Table 5) are the basic elements with which to assess cost effectiveness. Effectiveness refers to the merit of the work for erosion control. The heavy equipment work was the most cost effective. Other highly cost effective work items included waterbars, portions of the stream clearance project (see Evaluation of Stream Clearance), mulches and jute net application, and the winter maintenance program. Use of the Fresno dragline bucket was only cost effective when used at the site that could not be reached by the backhoe. At Site 22, lengthy Fresno bucket work was totally unnecessary because of easy backhoe access.

The sediment collection system, though it was well constructed and did operate up to expectations, was not cost effective because it did not prevent hillslope erosion and it probably did not significantly reduce in-channel deposition or downcutting. The collection system did store sediment that ultimately would have reached the Redwood Creek channel, but the quantity was insignificant compared to the amount of sediment now stored in Redwood Creek downstream of Airstrip Creek.

TABLE 5

DIRECT AND INDIRECT COSTS FOR EROSION CONTROL WORK

AIRSTRIP CREEK REHABILITATION PROJECT

Work Item	Cost
Labor hours directly involved with on-site work (Tables 1, 2, and 3)	$ 33,515
Heavy equipment rental (including operator and hauling to site)	4,930
Labor hours not directly involved with on-site work (tool maintenance, supply delivery, cooking, camp maintenance, accounting for person-hours, bookkeeping, consultation with Park Service personnel, worker-coordination meetings, report preparation)	28,049
Non-labor costs exclusive of heavy equipment (depreciation on equipment, fuel, vehicle mileage, supplies, use of livestock for hauling, camp costs)	16,361
Subtotal	$ 82,855
10% Fixed Fee Allowed For Profit	8,286
TOTAL CONTRACT PRICE	$ 91,141

Even without an evaluation of the revegetation work in terms of successful germination or propagation, we feel the planting and seeding for erosion control was not as cost effective as the application of mulch and jute netting. Mulch and jute net would have minimized rainsplash erosion and rilling on the recently disturbed sideslopes without seeding and planting. However, seeding and planting alone would not have produced similar erosion control benefits.

In summary, the cost-reimbursable payment process in the contract was perhaps the single least cost effective aspect of the contract. Not only did the Park Service pay for all direct and indirect costs, but a Park Service geologist worked full time to keep track of contract progress to make sure the project was completed within the budget. Under a fixed price contract, the incentive to complete the job within the designated budget would be the contractor's, not the Government's, responsibility. Some of the larger, more costly project items such as the sediment collection system, the stream clearance program, and the wattling, produced only partial or minimal erosion control benefits. On the other hand, some of the least expensive work items, such as heavy equipment work, waterbars, the mulch and jute netting, and the winter maintenance program, definitely provided erosion control benefits. Rocking of channels in this contract cost virtually nothing (Table 2) and was not very effective. We feel a more thorough and expensive rocking program aided by hauling larger rock to the sites with heavy equipment, and deeper channel excavations would have been highly cost effective. The trail system provided efficient access to work sites and was a definite benefit to contract work. Less than 10% of direct, on-site labor went into trail construction, and we feel the trail was cost effective, though a simpler trail would have served equally well.

Finally, we feel that this contract method, despite its disadvantages, provided unique benefits to both the local community and the Park Service. The contract afforded individuals in the local community the opportunity to propose their ideas for watershed rehabilitation, and it also allowed individuals to learn about erosion control through their own initiative. The National Park Service also learned a great deal about both contracting and erosion control methods by doing a portion of the 1979 erosion control work under the RFP cost-reimbursable process.

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APPENDIX I

GRASS SEED MIXTURES USED AT DIFFERENT SITES ON THE AIRSTRIP CREEK REHABILITATION UNIT

Wet Areas — Grass Mix A	Percent Seed Composition
Lolium perenne, perennial ryegrass	30
Dactylis glomerata, Potomac orchardgrass	30
Agropyron elongatum, tall wheatgrass	30
Agrostis palustris, creeping bentgrass	10

Intermediate Areas — Grass Mix B	Percent Seed Composition
Lolium multiflorum, annual ryegrass	40
Agropyron elongatum, tall wheatgrass	20
Bromus mollis, Blando brome	10

Dry Areas

Grass Mix B

(See above)

Areas Near Watercourses and Erosion Control Structures — Grass Mix C	Percent Seed Composition
Agrostis palustris, creeping bentgrass	30
Festuca ovina var. *duriuscula*, hard fescue	20
Agrostis tenuis, highland bentgrass	20
Lolium perenne, perennial ryegrass	20
Dactylis glomerata, Potomac orchardgrass	10